# Strategies to Improve Livestock Genetic Resources to Counter Climate Change Impact

25

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**Abstract**

Global diversity of livestock in the form of many different species and breeds in a variety of production environments is indicative of the fact that it has developed over time in sync with the ecosystem. The developing world is particularly enriched with livestock breed portfolio. Natural selection has mainly acted on fitness including adaptability and reproductive success, whereas selection practised by livestock keepers and animal breeders has been need based. As against highly structured breeding programmes and intensive selection in developed world, livestock of developing world have largely been subjected to differential selection pressures in the form of their ability to survive in harsh production environments and challenged inputs. The last few decades have witnessed large-scale erosion of livestock genetic diversity. Climate change (CC) through its direct and indirect effects including its mitigation measures is believed to have influenced the erosion. Faster loss of animal genetic diversity poses greatest threat to the sustainability of the sector. The presence of varied livestock species and their breeds with widely variable performances offers the opportunity for genetic improvement. In the absence of it, we risk progress in this sector. Reorientation of livestock breeding is required to address the issues of CC. Although resource-use efficiency is imperative, careful trade-off between livestock production, productivity and

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adaptability will be required. Breeding strategies for livestock genetic resources to counter CC impact will not be fundamentally different in the future. Natural stratification of species and breeds of livestock shall be an important guide in the design. Appropriate policy framework, large-scale cooperation in knowledge and resources and awareness will be crucial.

**Keywords**
Adaptability • AnGR • Breeding strategy • Conservation • Genetic improvement • Production system • Sustainability

Animal agriculture continues to remain as one of the most important sources for income generation and tool for nutritional security, livelihood and poverty alleviation in developing and least developed countries. Growth trend of industrial and organised mode of animal production in developed countries also confirms its ever-increasing and important role in food security. The livestock sector as a whole is dynamic and has grown over the period facing newer challenges, developing suitable strategies to curtail and circumvent it. Key ingredient in facing the challenges with resilience has been the flexibility of operation and diversity of production and production system. The swiftness of the production system to adjust has been the cornerstone that has been possible because of the many factors, one of the key of which is the diversity of gene pool in the form of many different livestock species and breeds of a species including crossbred and synthetic population. The dynamic livestock sector embraces for a relatively newer challenge – climate change (CC). Not only the livestock species but also its production system has evolved over hundreds of years facing climatic and weather variables and extremes. It may not be illogical to think that the sector will match the demands of CC through structural and functional change including its organic function. The key question that remains to be answered is the preparedness in the face of CC so that livestock production and productivity are not grossly affected. What is largely unexplored because of absence of authentic data and sufficient experimentation is whether the variable and veritable gene pool will continue to deliver the same goods and services with incremental growth without major change in case CC outpaces the inherent and serial adaptability of the livestock production and production system.

The pillar of the livestock improvement to meet the burgeoning needs of humankinds has been the improvement of genetics. The genetic improvement of livestock has been a function of natural selection and human intervention. Whereas fitness and adaptability have shaped the course of natural selection, livestock keepers and animal breeders have brought improvement through application of their wisdom, science and technologies. Although rate of genetic gain is slow and steady, it is relatively permanent and thus indispensable. The predominant motive in artificial selection has been need based; however, societal as well as ecological values of livestock might not have been overlooked while practising selection by their keepers. Key ingredient for selection to be effective and useful is variation in the population. The diversity and variability in the phenotype and genotype of livestock offers the opportunity for genetic improvement. The last few decades have witnessed unparallel loss of livestock genetic diversity for varied reasons. CC through its direct and indirect effects is supposed to have accelerated the erosion. Faster loss of animal genetic diversity poses greatest threat to the sustainability of animal agriculture directly and thereby to nutritional security and livelihood of its keepers along with high impact on the ecosystem.

In the following section, attributes of livestock genetic resources in interaction with climate and CC, analysis of practised breeding strategies and resultant priority of livestock genetic improvement issues with respect to climate resilience are discussed.

## 25.1 Interplay of Animal Genetic Resources (AnGR) and Climate (Change)

The diversity of livestock species and its many different breeds including the ones developed by its rearers and breeders is sufficiently indicative of the interplay of animal genetic resources (AnGR) with climate. Natural distribution pattern of livestock species and breeds has been a function of the ecosystem. Climate being an integral part of the ecosystem influencing production and reproduction, nutrient availability and disease pattern, the diversity of livestock species was ensured. Thus, the course of evolution has been in no stage insulated from the interaction with climate and its variables. Thirty-three mammalian and avian livestock species are described by Food and Agriculture Organization's (FAO) Domestic Animal Diversity Information System (DAD-IS). When we look at a particular livestock species, another discernible feature is the natural stratification of livestock breeds by climatic zones suiting to the macro-environment and based on production system and practice. FAO's global assessment of livestock breed diversity puts the figure to 7,040 local breeds and 1,051 transboundary breeds (FAO 2009). Developing countries host about two-thirds of breed portfolio. Further variability is explained by the selective expression of gene(s) depending on the climate and weather variables.

Livestock species has equally undergone the course of natural evolution determined by the fitness acting on selective reproductive success. Since the onset of domestication, humankind has used it to suit their diverse needs. Although the predominant motive has been the improvement in production and productivity, nontangible factors like sociocultural and environmental service have also importantly influenced livestock species and breed biodiversity portfolio. In the process, livestock has acquired necessary physical and physiological changes. When looked to the cellular level, it has resulted in differential display of genes, their action and interaction. In many cases, it has resulted in signature conformation with novel gene mutations.

### 25.1.1 Significance of Climate Change for the Management of AnGR

Livestock breeds have been conscientiously developed along with the climatic variables naturally. Whenever farming needs have defined the breeding objective, a healthy balance of production and productivity, feed efficiency, general vigour, disease tolerance and longevity has got predominance on macro-scale. Thus, both natural and artificial selection have largely been in sync with climate and production system so that it can produce goods and offer services and at the same time withstand climatic stress. For industrial or landless production system, other traits except production and productivity have not received due attention because of easy access to inputs. There are notable exceptions like the beef industry which has imbibed functional traits serially.

It is now well understood that the diversity of livestock species and breed portfolio offers the opportunity for facing challenges more effectively and helps in risk mitigation. In this connection, it is worthwhile to note that maximum livestock diversity is observed in developing and least developed countries with a variety of production systems like smallholder, mixed crop-livestock and pastoral offering diverse production, sociocultural and environmental services. In developed world, the portfolio has become limited suiting to industrial needs of milk, meat, egg and fibre. Thus, whereas local breeds along with traditional breeding system dominate developing and poor countries, limited transboundary breeds with global reach developed through scientific

well-structured breeding programmes are mostly seen in developed countries. Traditional production system is largely not protected for environmental variables and open grazing is popular in contrast to large-scale intensive production system which is mostly protected against environmental variables through shelter and control of microenvironments. Heterogeneous plant communities with widely variable nutritive values, crop residues, pasture feeding and low-quality forage characterise the feed type available to livestock in majority of the developing and poor countries as against concentrate, cereal, easily digestible fodder and good pasture in developed world which is largely not influenced by seasonal variability. When it comes to disease and parasitic challenges, tropical world is more unfavourable to its livestock as compared to temperate world.

The direct challenges posed by climatic variables like high temperature, humidity and restricted access to potable water and the indirect challenges such as low-quality feed and fodder, increased diseases and mortality have resulted in the development of livestock breeds which are well adapted in tropical world. Most of them can thrive well and produce a wide variety of goods and services. The range of goods include milk, meat, egg, wool and fibre, skin and hides, draught power and transport, manure for soil fertility and bio-fuel. The definition of the broad-based role of tropical and traditional livestock production system also includes a range of sociocultural services like insurance and asset function during emergencies, religious role, heritage, alternative system of medicinal use, sports and recreation, social status of owner and a host of environmental services like efficient use of crop by-products and residues, weed and shrub control, dispersal of seeds and constituent of cultural landscapes.

However, when enumerating the role and contribution of livestock by commonly agreed and easily comparable economic terms, it is by and large restricted to traded products only like milk, meat and egg. This has resulted in considerable undervaluation of it as a humankind asset function. Even in the absence of complete capture of the true value of the product and services offered by livestock resources, it is accepted beyond doubt that the genetic diversity of AnGR is vital for adapting production systems to future changes.

The relevance of maintaining diversity in AnGR for the present and the future remains with the fact that animals must be genetically well matched to production environments in which they are (to be) kept and able to meet the demands for products and services. Altered scenario under CC may require adjustment of breeding objectives and/or adaptation of husbandry practices, but genetic diversity always remains as a prerequisite for adapting production systems to future changes.

It may be appreciated that the projected challenges associated with CC like thermal stress, poor nutrition and increased disease risk will not be fundamentally different than what the livestock faces today specially for the tropical world. It becomes a major concern for the conditions that changes outpace the adaptability and/or the future portfolio of genetic diversity no longer offers the option to adapt because of being already lost.

Livestock rearing being one of the oldest professions of humankind gave rise to diverse production environment and systems. For all reasons, livestock husbandry has matched the expectation of nutritional security and livelihoods. However, ever-increasing demand for animal products with human population explosion led to unparallel demand leading to the so-called livestock revolution. The sector being dynamic has kept the pace, and CC for all purpose may add another layer of influence. Livestock revolution saw globalisation of livestock production led by the industrialised system of production in developed world. More than 90 % of genetic material exports originate from developed countries, and share of trade from developed to developing countries increased from 20 to 30 % between 1995 and 2005 (Gollin et al. 2008). The industrial system of livestock production produces 55, 68 and 74 % of global pork, eggs and poultry meat production, respectively, utilising internationally sourced animal genetics and feed and large-scale use of sophisticated technologies (FAO 2003; Steinfeld et al.

2006). Most of the developing and poor countries in the pursuit of purchasing genetic progress as short-cut instead of developing suitable animal germplasm using native genetic resources of their own has imported genetic materials of high producing ability which has otherwise been developed for production environments of developed world based on high-inputs. This led to the spread of elite and restricted genetic base to the world over, the so-called international transboundary breeds.

As compared to industrial livestock production, majority of the developing and poor countries basically harbours smallholder production along with pastoral system of livestock rearing with a host of native livestock breeds known for their resilience. These native breeds have always been a cultural entity rather than a defined class of homogenous population. The so-called livestock-based development programmes in developing and poor countries based on import of genetic progress led to severe erosion of their own livestock diversity. Although developing countries host about two-thirds of breed portfolio, about 9 % of reported breeds are extinct and 20 % are currently classified as being at risk globally. The risk status of 36 % of breeds is unknown (FAO 2009). About 31 % of cattle breeds, 35 % of pig, 38 % of chicken and 33 % of horse breeds are currently at risk or already extinct (FAO 2009).

Although short- and medium-term gain of importer countries can never be denied, its long-term effect has already shown vulnerability whereby the improved livestock struggles to retain its superiority with relatively poor inputs and services in different production environments.

The growing dichotomy between large-scale intensive livestock production and smallholder mixed crop-livestock or pastoral system of livestock production further adds uncertainty and vulnerability to future changes. These may warrant redefining the role and value of AnGR in broadest possible term including its sociocultural and environmental value. Most native livestock breeds of developing and poor countries produce at low to medium level with challenge inputs – poor feed, fodder and pasture, high disease incidences and worm load and higher mortality. However, sufficient within-breed variation exists, allowing exploit of additive genetic variation through selective breeding.

More perplexing is the fact that livestock production both contributes to and is affected by CC. Eighteen per cent of global GHG emissions are attributed to livestock via land use and land-use change which includes grazing, feed crop production, manure management and enteric fermentation (FAO 2006a, 2010a).

Although it is widely understood that CC will affect the product and services rendered by diverse livestock species and breeds, regrettably it is yet to be integrated to the adaptation and mitigation strategies of CC. One of the biggest challenges in quantifying the role of CC on livestock is the absence of quality data and appropriate model. Although adaptation traits are widely covered, in many a case, they are restricted to anecdotal evidences and detailed data of it along with thermo-neutral zone (TNZ) is not available. Again, because of globalisation of animal genetics, mainly by international transboundary breeds, the geographical distribution of the breed(s) is overlaid by diverse production systems. Further, they often have similar environmental envelopes since several species have been domesticated in the same region. Another bigger void is that many stakeholders do not consider CC as a possible threat to the long-term sustained use of livestock biodiversity and the product and services thereof.

### 25.1.2 Challenges Associated with Climate Change to AnGR

As discussed earlier, selection in general has largely been in sync with climate and production system so that it continues to produce goods and services in the presence of predictable stresses with time horizon of its development. However, many a different factors influence it. There is a wide variation in adaptability of different livestock species and breeds to stressors. Most native animals of tropical countries have remarkable